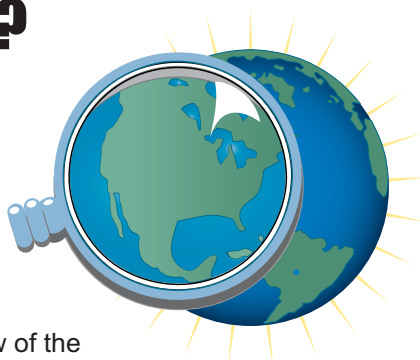




## How close is safe? Buffer zone development



### Investigation Overview

This investigation provides an overview of the local effects of volcanism. Students categorize causes, effects, and responses to volcanic hazards by focusing on the interdependence of all Earth systems. Using various remotely sensed images, students observe the visible effects of Mount St. Helens' 1980 eruption over time. Based on these observations students identify a buffer zone to designate safer locations for development.

Time required: Two 45-minute sessions

### Materials/Resources

Log 1, Briefing, and Log 2 (one copy per student)

One set of Cause and Effect Statements, cut into strips (per group)

Poster paper for categorization (per group)

Images needed (one copy per group)

Figure 1: Mount St. Helens, March 1980, before the eruption

Figure 2: Mount St. Helens, June 1980, after the eruption

Figure 3: Aerial photograph of 1980 damage to Mount St. Helens

Figure 4: Mount St. Helens in 1999

Figure 5: Mount St. Helens hazards map

Blank overhead transparency (one per group)

Five different colors of transparency markers

Ruler (one per group)

Masking tape

### Content Preview

Geographers conceptualize Earth in terms of physical systems (the lithosphere, the biosphere, the hydrosphere, and the atmosphere) and human systems that are unified in a single, highly interconnected system. Changes in one system lead to changes in other systems, with an impact on a variety of scales, from local to regional to global. Volcanoes provide an outstanding opportunity to highlight the relationships between human and physical systems and how humans deal with natural hazards.

### Geography Standards

#### **Standard 15: Environment and Society**

##### ***How physical systems affect human systems***

- Analyze ways in which human systems develop in response to conditions in the physical environment.
- Describe the effect of natural hazards on human systems.

#### **Standard 7: Physical Systems**

##### ***The physical processes that shape the patterns of Earth's surface***

- Predict the consequences of a specific physical process operating on Earth's surface.

#### **Standard 3: The World in Spatial Terms**

##### ***How to analyze the spatial organization of people, places, and environments on Earth's surface***

- Analyze and explain distributions of physical and human phenomena with respect to spatial patterns, arrangements, and associations.

### Geography Skills

#### **Skill Set 4: Analyze Geographic Information**

- Interpret information obtained from maps, aerial photographs, satellite-produced images, and geographic information systems.
- Interpret and synthesize information obtained from a variety of sources.

#### **Skill Set 5: Answer Geographic Questions**

- Make generalizations and assess their validity.

## Classroom Procedures

### Beginning the Investigation

1. Explain that the purpose of the module is to investigate the effects of volcanoes. Geographers are vitally interested in learning about changes caused by volcanoes at different scales, from the local (immediately adjacent to volcanoes) to the global (world atmospheric conditions affected by volcanic eruptions). Give students time to discuss what they already know about volcanoes and their local-to-global effects.
2. Distribute **Log 1** and have students read the background and objectives. Distribute the **Briefing** and have students read the narrative account of Mount St. Helens' 1980 eruption. You may ask students to take turns reading this dramatic story in a "reader's theater."
3. NASA monitors volcanoes because of their significant effect on people and the environment. Introduce or review the following terms used to describe the environment in Earth-systems terms:
  - Hydrosphere: Earth system dealing with water (hydro-), including surface water systems (lakes, rivers, oceans) and frozen water (glaciers, polar ice caps) as well as water beneath the surface of Earth (aquifers, groundwater, etc.)
  - Lithosphere: Earth system dealing with land (soil, rocks, etc.)
  - Atmosphere: Earth system dealing with air
  - Biosphere: Earth system dealing with plant and animal life (flora and fauna)

Have students record definitions in the Log.

4. Divide the class into groups of 3-5 and distribute the Cause and Effect Statements, cut into strips, one set per group.

Causes	Effects	Human Responses
Structure of the Volcano	Effects on... Lithosphere	Clean-Up Efforts
The Eruption Event	Hydrosphere	Responses to Environmental Hazards
	Biosphere	Monitoring Efforts
	Atmosphere	
	Human Activities	

- Review the statements with students to make sure they understand the vocabulary.
  - Ask students to organize the strips into three groups: Causes, Effects, and Human Responses. Some statements may require a fine distinction between "cause" and "effect"; develop working definitions as a class if necessary. (Suggested definitions: Cause—incidents that lead up to or are related to the actual eruption event. Effect—incidents that result from the actual eruption event).
  - Students complete item 3 in the Log.
5. Using large sheets of poster paper and tape, have students classify the statements again, this time into more specific categories shown in **Log 2: Cause and effect organizer**. Be sure that all students understand the categories. Discuss the types of cues they would use to determine a statement's classification. For example, students should identify that statements dealing with the plant and animal life of the area would be placed under "Effects on the Biosphere."
  - Students record their categorizations on **Log 2**.
  6. Ask selected groups to share their classifications with the class. If groups disagree about a statement's classification, allow them to explain their underlying thought process. Use points of disagreement to reinforce the concept that Earth systems function interdependently, so it is sometimes difficult to determine which "-sphere" is being affected.
  7. Debrief this activity by highlighting that effects and consequences such as the ones listed require considerable lengths of recovery time after an eruption. How people prepare for and respond to volcanic eruptions is vital to the safety and productivity of an area. Explain that NASA images show the extent of damage after an eruption and provide data useful to lessen the human impacts of possible future eruptions.

### Developing the Investigation

8. Distribute **Figure 1: Mount St. Helens, March 1980, before the eruption** to each group. Explain that this is a false color Landsat image, which means that the colors on the image are not the same as would appear to the human eye. In this image, vegetation is red.

9. Guide students in interpreting the image using the following questions:
- What would you look for to identify a river? (*Look for meanders or curves in a line.*)
  - How would you identify the location of the volcano's peak? (*Look for dark gray or black areas surrounded by little vegetation. These represent snow and glaciers that are on top of the volcano.*)
  - How would you find areas of vegetation? (*Look for red areas since this is a false color image and living vegetation is reddish.*)
  - Why might some areas of vegetation have straight boundaries? (*They are probably boundaries for agricultural land or some other managed landscape.*)
- Have students complete item 4 in the Log.
10. Ask students to review the Cause and Effect Statements they organized earlier in the investigation. Have them record in their log three things that they would expect to be able to observe in a false color image taken after an eruption. Allow students to discuss their predictions with the class. They should mention things like:
- less red color because much of the vegetation was killed by the blast
  - changes in the course of rivers or the development of new lakes as debris obstructed the flow of rivers
  - changes in the shape of the volcano due to landslides
11. Distribute a blank overhead transparency and transparency marker to each group. Instruct students to mark the corners of **Figure 1** on the transparency to aid in lining up other images later.
12. Ask students to locate the summit of the volcano (*in the lower left area of the image*) and then trace the extent of the volcano. Students should create a key at the bottom of the transparency for each color used throughout the investigation.
13. Explain the concept of a buffer. A buffer provides an area to absorb negative consequences of physical or human activities. For example, tree buffers can serve to protect a neighborhood from highway traffic and noise, while an uninhabited buffer area can protect people from some dangers of natural hazards.
- In a different colored transparency marker, ask students to sketch the area they think should be the buffer zone for safety around Mount St. Helens.
14. Distribute **Figure 2: Mount St. Helens, June 1980, after the eruption**.
- Instruct students to compare this figure to **Figure 1**.
  - Have students discuss their reactions to the changes from **Figure 1** to **Figure 2**. In what ways was the environment disturbed and disrupted by the eruption? In what ways was vegetation altered? The flow of rivers? Students should check to see the changes they predicted. Were their predictions accurate?
  - Have students measure the areal extent of the damage in four directions using a ruler and the scale of the image.
  - Have students place the transparency on **Figure 2**, lining up the corner marks.
  - In another color, have students trace the boundary of the extent of the disruption and devastation brought on by the eruption. Ask how effective their buffer would have been for this particular eruption.
15. Have students review the Cause and Effect Statements again to imagine what the area in this image would look like at ground level. Then, display **Figure 3: Aerial photograph of 1980 damage to Mount St. Helens** to illustrate what the land looked like after the eruption.
16. Ask students to formulate a hypothesis about the present environment around Mount St. Helens. What would it look like today? Using a new color transparency marker, have students draw in with dashed lines how much of the area they think probably still shows effects of the 1980 eruption today.
17. Distribute **Figure 4: Mount St. Helens in December 1999**. Students need to line this image up with the lower right corner of their transparency. Explain that instead of vegetation appearing red, in a true color image vegetation looks green like it does in the real world. Ask students to compare this image with the previous two. How has the local environment changed? Ensure that students notice the vegetation regrowth in some areas. Where has regrowth occurred, and where has it not? Have students look for patterns and explanations for the areas of regrowth. (*Explanations could include: The impact was more severe and lasting in the direction of the blast. The area directly adjacent to the volcano was slowest to grow vegetation. Areas along the river and surrounding Spirit Lake have begun to recover vegetation.*)

18. Using a different color marker, ask students to draw a second safe buffer zone around the volcano applying this new information. Students should record their justification for the boundary by stating which effects are being addressed by their new buffer zone.

### Concluding the Investigation

19. Compare the second buffer zone to the buffer they drew originally. Ask how many groups made their second buffer zone bigger.

Students may assume that the next eruption will affect the same area, which would not necessarily be the case. Ask what other information students or scientists would need to create a buffer zone that took this possibility into account.

20. Remind students that scientists are constantly monitoring changes with volcanoes, hoping that new information will help the area be safer and more prepared for potential eruptions. Using data from several different years allows people to make wiser decisions. If students changed their buffer zone, they understand the need to respond to additional information about dangers.
21. Circulate **Figure 5: Mount St. Helens hazards map** for students to compare their second buffer zone area with the hazard areas identified by the U.S. Geological Survey.

22. Ask students to review the Cause and Effect Statements they used in the beginning of the investigation. Have them identify which effects may have been less of a problem if there had been a sufficient buffer zone in place before the 1980 eruption of Mount St. Helens. Have students record their answers in their Log. Provide time for whole group discussion of the possible effects and limitations of buffer zones.

### Background

Volcanoes are dangerous, but they are also very important to humans. Volcanic eruptions contribute substantially to soil fertility. In the Andes, many people live on the flanks or at the foot of active composite volcanoes, largely because of the fertility of the volcanic deposits. The same is true in the Philippines where residents near active volcanoes like Mount Mayon and Mount Taal regularly move away during eruptions, only to move right back when the danger subsides. These two cases present good examples of how people learn to live and adapt to hazardous environments.

Mount St. Helens is one of many composite (strato-volcano) volcanoes in the Cascade Range of the Northwest United States. Mount St. Helens has been one of the most active volcanoes in the Pacific Northwest although before the eruption in May 1980, it had been dormant since 1857.

	Shield	Composite/ Stratovolcanoes	Cinder Cones
Formation/ Location	Massive fluid lava flows and slowly builds up a gently sloping volcanic shape.	Built from both explosive eruptions and quieter eruptions. Layers of tephra (ash, cinders, and other material blown into the air) alternate with layers of lava to create steep-sided, often symmetrical cones.	Made primarily from explosive eruptions of lava. Blown into the air, the erupting lava breaks apart into the small fragments known as cinders. The fallen cinders accumulate into a cone around the volcano's central vent (the "hole in the ground" from which the lava emerged).
Location	Primarily located along tectonic spreading centers or at "hot spots."	Stratovolcanoes are located primarily along tectonic subduction zones, where two plates slowly collide.	Not associated with any particular tectonic activity. Some are found near current tectonic boundaries, and others are near old boundaries.
Examples	Kilauea, Mauna Loa (Hawaii)	Mount Fuji (Japan), Mount St. Helens (Washington)	Sunset Crater (Arizona), Capulin Mountain (New Mexico)



More detailed information about the Cascade Range, Mount St. Helens, and the 1980 eruption can be found at the USGS/Cascade Volcano Observatory web site: <<http://vulcan.wr.usgs.gov/Volcanoes/MSH/framework.html>>

## Evaluation

### Statement Categorization

Following are suggested categorizations and justifications. Some statements are listed in more than one category to illustrate the multiple categorizations that may occur.

#### Causes

##### Structure of the Volcano

15. Composite volcanoes erupt explosively. (*Statement describes Mount St. Helens' volcano type.*)
16. Composite volcanoes are made of alternating layers of lava, ash, and other volcanic debris. (*This layering of debris from former eruptions gives the volcano its structure as well as providing considerable material to spew during an eruption.*)
18. Magma contains high concentrations of gas that may cause an explosion that breaks magma into pumice and tiny ash particles. (*This statement describes magma behavior in a composite volcano.*)

##### The Eruption Event

2. The mountain "awoke" with a series of steam explosions and bursts of ash. (*This was a cause leading to the effect of an enormous ash cloud that traveled the globe [10, 14] and the development of global ash monitoring stations [9].*)
3. The mountain shook from a strong, magnitude 4.2 earthquake. (*This statement is associated with activity immediately preceding the eruption.*)
4. The entire face of the mountain broke free and slid downward in a giant rock avalanche. (*Depending on the interpretation, this statement could apply to the conditions surrounding the eruption or an effect of the eruption on the lithosphere. Students could justify placement in either of these categories based on their distinction between a physical cause and effect.*)
5. The lava contained dissolved water that exploded into superheated steam. (*This was a cause leading to the effect of an enormous ash cloud that traveled the globe [10, 14] and the development of global ash monitoring stations [9].*)

19. Within hours of the blast, mixtures of gas, pumice, and ash swept down the north side of the volcano at speeds up to 160 kilometers/hour (100 miles per hour) and at temperatures of over 648° C (1200° F). (*While this mentions a timeline of "within hours of the blast," the speed and temperature of the materials caused many of the devastating effects listed.*)

#### Effects

##### Lithosphere

1. Volcanic deposits literally reshaped the entire region around the mountain. (*The term deposits is key in this statement to suggest actions after the actual eruption.*)
13. Enormous mudflows gushed down the mountain. (*Mudflows are made up of primarily materials from the lithosphere, but students may see this as an interaction between the lithosphere and the hydrosphere.*)
20. A fan-shaped pumice plain developed to the north and directly in front of the crater. (*The deposition of the pumice reshaped the physical landscape in front of the crater.*)
21. Layers of pyroclastic flow (pumice, ash, and gas) were deposited as thick as 20 meters (60 feet) deep along the north side of the volcano. (*Volcanic deposits, again, affecting the landscape.*)

##### Hydrosphere

22. The Columbia River was closed to freighter traffic for several days to remove debris. (*The reference to freighter [shipping] traffic makes this statement fit better within effects on human activities than effects on the hydrosphere, but students may initially associate the river with the hydrosphere.*)
28. A debris avalanche blocked the natural outlet of Spirit Lake. (*The natural circulation processes of Spirit Lake were affected.*)
29. Several new lakes were formed by debris deposits, but these natural dams were unstable and could fail and flood the streams. (*Students should recognize that actions such as natural or artificial damming have consequences such as potential failures, which ultimately can add considerable stress to the rest of the river system.*)

##### Biosphere

7. Thousands of deer, elk, bear, and other animals died. (*Fauna are all part of the biosphere.*)
8. Almost 594 square kilometers of forest were destroyed. (*Flora are part of the biosphere.*)

17. Plant growth was severely slowed for years after the eruption. *(The soil must have time to recover for the plant life to return. At first, though, only very short hardy plants will be able to survive.)*
23. Trees were stripped from the hillsides as far as 10 kilometers from the volcano. *(The blast literally tore many trees out of the ground.)*
24. Around the edges of the blowdown zone, trees were killed simply by the intense heat of the blast. These trees are called Standing Dead. *(Beyond the area where trees were torn out of the ground, trees were singed and killed. The Standing Dead resembled deciduous trees during the winter, except that they were not just dormant.)*

#### Atmosphere

10. Tiny ash particles were thrust 24 kilometers into the sky and continued for about nine hours. *(Material was being added to the atmosphere.)*
14. Small ash particles reached the eastern United States within three days of the blast and circled the globe within two weeks. *(This statement illustrates the global extent of the atmospheric impact. Material from an eruption in the United States traveled around the globe in less than two weeks.)*

#### Human Activities

6. Shipping channels were blocked. *(Students may place this statement in either the hydrosphere or in human activities. This statement speaks more directly to the human activities on the river rather than effects on the hydrology of the area, so it is better categorized here.)*
11. Many communities and agricultural areas were affected by falling ash. Machinery and crops were damaged. *(The emphasis on agriculture and technology focuses this statement on the effects on human activities.)*
12. A small airplane narrowly avoided disaster when the pilot put the plane into a steep dive to gain speed and turned south, away from the ash cloud. *(This statement refers to human activities in the atmosphere but is better categorized as an effect on human activities.)*
22. The Columbia River was closed to freighter traffic for several days to remove debris. *(The reference to freighter, shipping traffic makes this statement fit better within human activities than effects on the hydrosphere.)*

#### Human Responses

##### Clean-Up Efforts

25. From May to September 1980, the U.S. Army Corps of Engineers removed 32 million cubic meters of debris from the Cowlitz River. *(The Corps was working to free up shipping channels again.)*

##### Environmental Hazards

26. Levees and retaining structures were built to control sediment and debris deposits. This prevents deposits from clogging the rivers and hindering boat traffic or causing flooding downstream. *(While levees are designed to control floods and manage water resources, it is important for students to remember that these structures sometimes fail just as natural dams sometimes do [29]. Settling outside the floodplain is the safest way to minimize flood damage.)*
27. Flood gates were installed to prevent potential flooding of Spirit Lake caused by future volcanic activity. *(Efforts by humans to control natural environmental hazards.)*
30. A fish transport system was built to help fish get around the sediment-retention structure. This provided safe passage for salmon and steelhead returning from the sea. *(This system was an attempt to reconnect the migration path of fish that had been disrupted by human-built structures. Students should realize that human actions also have effects on the interactions of all the spheres, which should be minimized as much as possible.)*

##### Monitoring Efforts

9. A global network of Volcanic Ash Advisory Centers was created to observe volcanic eruptions in order to improve aircraft safety. *(The VAAC system was created to address the effects of worldwide volcanic ash hazards.)*
31. Scientists carefully watch the activity of magma under Mount St. Helens. Nonetheless, heat from the magma has led to avalanches (melting snow) and explosions of steam (heated water) without warning. *(Scientists monitor for changes that often lead up to volcanic eruptions to attempt to give some warning before the next one.)*
32. The U.S. Geological Survey and University of Washington are watching for volcanic activity of Mount St. Helens. Information on lahar (mud slides) and flood hazards is now collected by

the USGS and the National Weather Service who then issue warnings. (*This statement reflects the interagency concern with monitoring volcanic activity*).

### Suggested Key for Log 1

2. Hydrosphere: Earth system dealing with water  
Lithosphere: Earth system dealing with land  
Atmosphere: Earth system dealing with air  
Biosphere: Earth system dealing with plants and animals, flora and fauna
5. Responses will vary but might include: loss of vegetation, changes in shape of the volcano, changes in the course of the river, formation of additional lakes.
8. Observations will vary.
10. Student estimates will vary but should include reference to changes in the shape of the volcano, lack of trees, debris flow.
12. Students should observe that Figure 4 is true color; thus vegetation is green in this image rather than red.
13. Vegetation regrowth can be seen primarily to the northwest of the volcano. Directly north of the volcano is still gray because the area has not yet recovered.
14. Reasons may vary but should be evaluated for soundness of the reasoning. A sample answer: The area closest to the blast side of the volcano was most severely disrupted by the eruption as shown by loss of vegetation and other items, so it is taking the longest time to recover.
15. Student justifications will vary, but the response should include why they chose to make the new buffer zone larger or smaller than the previous one. Answers should also include consideration for the areas of regrowth. For example, areas that are green now were not "safe" during 1980, so establishing a buffer based only on Figures 1 or 4 would be misleading.
16. Student responses should illustrate reasoning and careful evaluation of the significant issues.
17. The paragraph should address both the importance

and limitations of buffer zones. On one hand, buffers protect humans and human activities from direct hazards. However, there are numerous effects of volcanic eruptions that a buffer cannot address such as effects on the various -spheres. By its nature, a buffer zone addresses natural hazards from a human perspective alone, although humans are not the only living things affected by natural hazards. This paragraph can also be evaluated for grammar and composition.

### Related NASA Resources

<http://volcano2.pgd.hawaii.edu/eos/> Earth Observation System Volcanology Homepage, provides comparative information on a variety of volcanoes under study. Includes eruption data as well as satellite and aerial images of each.

### Related Resources

<http://vulcan.wr.usgs.gov/Volcanoes/MSH/framework.html> Links to information about Mount St. Helens. Includes details of the 1980 eruption, maps and graphics of the Cascades Volcanoes, monitoring efforts, and more.

[http://vulcan.wr.usgs.gov/Volcanoes/MSH/May18/summary\\_may18\\_eruption.html](http://vulcan.wr.usgs.gov/Volcanoes/MSH/May18/summary_may18_eruption.html) Summary of the 1980 eruption event, including measurements and extent of damage

<http://volcano.und.nodak.edu/vwdocs/msh/msh.html> Mount Saint Helens Homepage

<http://edcwww.cr.usgs.gov/earthshots/slow/MtStHelens/MtStHelens> Landsat progression of images with additional pictures of selected sites

[http://volcano.und.nodak.edu/vwdocs/volc\\_images/img\\_st\\_helens\\_bw.html](http://volcano.und.nodak.edu/vwdocs/volc_images/img_st_helens_bw.html) Dramatic black and white picture of eruption and ash cloud

<http://www.avo.alaska.edu/avo3/atlas/atlindex.htm> Alaskan Volcano Observatory, outstanding images and text about all volcanoes in Alaska, the Aleutian Islands, and Kamchatka Peninsula. Regional and local maps. Images of volcanoes, their eruptions, and the effects on the nearby human populations

[http://volcano.und.nodak.edu/vwdocs/volc\\_images/volc\\_images.html](http://volcano.und.nodak.edu/vwdocs/volc_images/volc_images.html) Volcano World page with searchable world map. Students can search for volcanoes by region, country, name, etc. Provides useful information and images from a variety of sources.



## Module 1, Investigation 1:

### Cause and effect statements

1. Volcanic deposits literally reshaped the entire region around the mountain.
2. The mountain “awoke” with a series of steam explosions and bursts of ash.
3. The mountain shook from a strong, magnitude 4.2 earthquake.
4. The entire face of the mountain broke free and slid downward in a giant rock avalanche.
5. The lava contained dissolved water that exploded into superheated steam.
6. Shipping channels were blocked.
7. Thousands of deer, elk, bear, and other animals died.
8. Almost 594 square kilometers of forest were destroyed.
9. A global network of Volcanic Ash Advisory Centers was created to observe volcanic eruptions in order to improve aircraft safety.
10. Tiny ash particles were thrust 24 kilometers into the sky and were airborne for about nine hours.
11. Many communities and agricultural areas were affected by falling ash. Machinery and crops were damaged.



12. A small airplane narrowly avoided disaster when the pilot put the plane into a steep dive to gain speed and turned south, away from the cloud.

13. Enormous mudflows gushed down the mountain.

14. Small ash particles reached the eastern United States within three days of the blast and circled the globe within two weeks.

15. Composite volcanoes erupt explosively.

16. Composite volcanoes are made of alternating layers of lava, ash, and other volcanic debris.

17. Plant growth was severely slowed for years after the eruption.

18. Magma contains high concentrations of gas that may cause an explosion that breaks magma into pumice and tiny ash particles.

19. Within hours of the blast, mixtures of gas, pumice, and ash swept down the north side of the volcano at speeds up to 160 kilometers per hour (100 miles per hour) and at temperatures over 648° C (1200° F).

20. A fan-shaped pumice plain developed to the north and directly in front of the crater.

21. Layers of pyroclastic flow (pumice, ash, and gas) were deposited as thick as 20 meters deep along the north side of the volcano.

22. The Columbia River was closed to freighter traffic for several days to remove debris.

23. Trees were stripped from hillsides as far as 10 kilometers from the volcano.

- |   |
|---|
| 24. Around the edges of the blowdown zone, trees were killed simply by the intense heat of the blast. These trees are called Standing Dead.   |
| 25. From May to September 1980, the U.S. Army Corps of Engineers removed 32 million cubic meters of debris from the Cowlitz River.  |
| 26. Levees and retaining structures were built to control sediment and debris deposits. This prevents deposits from clogging the rivers and hindering boat traffic or causing flooding downstream.  |
| 27. Flood gates were installed to prevent potential flooding of Spirit Lake caused by future volcanic activity.   |
| 28. A debris avalanche blocked the natural outlet of Spirit Lake.   |
| 29. Several new lakes were formed by debris deposits, but these natural dams were unstable and could fail and flood the streams.  |
| 30. A fish transport system was built to help fish get around the sediment-retention structure. This provided safe passage for salmon and steelhead returning from the sea.   |
| 31. Scientists carefully watch the activity of magma under Mount St. Helens. Nonetheless, heat from the magma has led to avalanches (melting snow) and explosions of steam (heated water) without warning.  |
| 32. The U.S. Geological Survey and University of Washington are watching for volcanic activity of Mount St. Helens. Information on lahar (mud slides) and flood hazards is now collected by the USGS and the National Weather Service who then issues warnings. |



Volcanoes are like good news, bad news jokes. The good news is that they offer humans benefits such as rich soil. The bad news is that they are very destructive when they erupt. Because of this contradiction between productivity and destruction, areas around volcanoes need to be evaluated for safety. Creating a safety zone around a volcano helps to minimize a volcano's effect on humans. Creating a safety or buffer zone, however, requires information about the extent of previous eruptions compared to human settlement patterns. In this investigation you use data at different scales to study the impact of volcanic eruptions on the environment and its inhabitants in order to establish a buffer zone.

- categorize the causes and effects of volcanic eruptions and human responses to them,
- measure the extent of damage of the Mount St. Helens 1980 eruption, and
- analyze images of a volcano to suggest a settlement buffer zone.

1. Read the account of the Mount St. Helens 1980 eruption.
2. Define the following elements of Earth's physical systems:

biosphere: \_\_\_\_\_

- | Causes | Effects | Human Responses |
|--------|---------|-----------------|
|        |         |                 |

1